



39

The Proceedings
OF
THE INSTITUTION OF
ELECTRICAL ENGINEERS

FOUNDED 1871: INCORPORATED BY ROYAL CHARTER 1921

ISSUED IN THREE PARTS AS FOLLOWS:

Part A. POWER ENGINEERING (*February, April, etc.*)

Part B. ELECTRONIC AND COMMUNICATION ENGINEERING (INCLUDING RADIO ENGINEERING)
(*January, March, etc.*)

Part C. INSTITUTION MONOGRAPHS (*March and September only*)

PART B
ELECTRONIC AND COMMUNICATION ENGINEERING
(INCLUDING RADIO ENGINEERING)

VOLUME 107, 1960

PUBLISHED BY THE INSTITUTION, SAVOY PLACE, LONDON, W.C.2

The Institution of Electrical Engineers

FOUNDED 1871

INCORPORATED BY ROYAL CHARTER 1921

PATRON: HER MAJESTY THE QUEEN

COUNCIL 1959-1960

President

SIR WILLIS JACKSON, D.Sc., F.R.S.

Past-Presidents

W. H. ECCLES, D.Sc., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGUMBE, T.D.
J. M. DONALDSON, M.C.
PROFESSOR E. W. MARCHANT, D.Sc.
H. T. YOUNG.
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng., LL.D.
J. R. BEARD, C.B.E., M.Sc.
SIR NOEL ASHBRIDGE, B.Sc.(Eng.).
SIR HARRY RAILING, D.Eng.
P. DUNSHEATH, C.B.E., M.A., D.Sc.(Eng.), LL.D.

SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROFESSOR E. B. MOULLIN, M.A., Sc.D., LL.D.
SIR ARCHIBALD J. GILL, B.Sc.(Eng.).
SIR JOHN HACKING.
COL. B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.Sc.(Eng.), F.C.G.I.
SIR JOSIAH ECCLES, C.B.E., D.Sc.
THE RT. HON. THE LORD NELSON OF STAFFORD.
SIR GORDON RADLEY, K.C.B., C.B.E., Ph.D.(Eng.).
S. E. GOODALL, M.Sc.(Eng.), F.Q.M.C.

Vice-Presidents

O. W. HUMPHREYS, C.B.E., B.Sc.
G. S. C. LUCAS, O.B.E., F.C.G.I.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C.*, LL.D., B.Sc.

C. T. MELLING, C.B.E., M.Sc.Tech.
A. H. MUMFORD, O.B.E., B.Sc.(Eng.).

Honorary Treasurer

E. LEETE.

Ordinary Members of Council

PROFESSOR H. E. M. BARLOW, Ph.D., B.Sc.(Eng.).
C. O. BOYSE, B.Sc.(Eng.).
PROFESSOR M. W. HUMPHREY DAVIES, M.Sc.
SIR JOHN DEAN, B.Sc.
L. DRUCQUER.
J. M. FERGUSON, B.Sc.(Eng.).
D. C. FLACK, B.Sc.(Eng.), Ph.D.
J. S. FORREST, D.Sc., M.A.
R. J. HALSEY, C.M.G., B.Sc.(Eng.), F.C.G.I.
J. B. HIGHAM, Ph.D., B.Sc.
R. A. HORE, M.A., B.Sc.

F. C. MCLEAN, C.B.E., B.Sc.
B. L. METCALF, B.Sc. (Eng.).
J. R. MORTLOCK, Ph.D., B.Sc.(Eng.).
THE HON. H. G. NELSON, M.A.
R. H. PHILLIPS, T.D.
H. V. PUGH.
J. R. RYLANDS, M.Sc., J.P.
G. A. V. SOWTER, Ph.D., B.Sc.(Eng.).
C. E. STRONG, O.B.E., B.A., B.A.I.
D. H. TOMPSETT, B.Sc.(Eng.).

Chairmen and Past-Chairmen of Sections

Electronics and Communications:

M. J. L. PULLING, C.B.E., M.A.
†G. MILLINGTON, M.A., B.Sc.

Measurement and Control:

PROFESSOR A. TUSTIN, M.Sc.
†J. K. WEBB, M.Sc.(Eng.), B.Sc.Tech.

Supply:

J. R. MORTLOCK, Ph.D., B.Sc.(Eng.).
†D. P. SAYERS, B.Sc.

Utilization:

T. E. HOUGHTON, M.Eng.
†R. A. MARRYAT, B.Sc.(Eng.).

Chairmen and Past-Chairmen of Local Centres

East Midland Centre:

D. H. PARRY, B.Sc.
†D. E. LAMBERT, B.Sc.(Eng.).

Mersey and North Wales Centre:

T. A. P. COLLEDGE, B.Sc.(Eng.).
†J. COLLINS.

North Midland Centre:

PROFESSOR G. W. CARTER, M.A.
†J. D. NICHOLSON, B.Sc.

North-Eastern Centre:

H. WATSON-JONES, M.Eng.
†A. T. CRAWFORD, B.Sc.

North-Western Centre:

F. H. HUTCHINSON, M.Eng.
†PROFESSOR F. C. WILLIAMS, O.B.E.,
D.Sc., D.Phil., F.R.S.

Northern Ireland Centre:

T. S. WYLIE.
†D. S. MCILHAGGER, Ph.D., M.Sc.

Western Centre:

H. JACKSON, B.Sc.(Eng.).
†R. W. STEEL.

† Past-Chairman

Scottish Centre:

L. A. AKED, M.B.E.
†R. J. RENNIE, B.Sc.

South Midland Centre:

G. F. PEIRSON.
†L. L. TOLLEY, B.Sc.(Eng.).

Southern Centre:

W. D. MALLINSON, B.Sc.(Eng.).
†G. BISHOP, B.Sc.

Secretary

W. K. BRASHER, C.B.E., M.A., M.I.E.E.

Principal Assistant Secretary

F. C. HARRIS.

Deputy Secretary

F. JERVIS SMITH, M.I.E.E.

Editor-in-Chief

G. E. WILLIAMS, B.Sc.(Eng.), M.I.E.E.

CONTENTS

VOL. 107, PART B

1960

	PAGE		PAGE
The President's Inaugural Address. Sir Willis Jackson, F.R.S.	1	Discussion on the above three papers and on 'The Gain of Travelling-Wave Ferromagnetic Amplifiers' before the Electronics and Communications Section	123
Chairmen's Addresses:		The Propagation of High-Frequency Radio Waves to Long Distances. F. Kift	127
Northern Ireland Centre. T. S. Wylie	14	V.H.F. Field-Strength Measurements over Paths in the Irish Sea involving Mountain Obstacles. J. K. S. Jowett, B.Sc.(Eng.)	141
Mersey and North Wales Centre. T. A. P. Colledge, B.Sc.(Eng.)	16	A Method of Amplitude and Phase Measurement in the V.H.F.-U.H.F. Band. G. D. Monteath, B.Sc., D. J. Whythe, B.Sc.(Eng.), and K. W. T. Hughes, B.Sc.	150
Southern Centre. W. D. Mallinson, B.Sc.(Eng.)	19	Fundamental and Harmonic Distortion of Waves Frequency-Modulated with a Single Tone. R. G. Medhurst, B.Sc.	155
Discussion on 'The Relation between Picture Size, Viewing Distance and Picture Quality', before the North-Western Electronics and Communications Group	19	Post Office Valves for Deep-Water Submarine Telephone Repeaters. M. F. Holmes, B.Sc., and F. H. Reynolds, B.Sc.(Eng.)	165
Discussion on 'A Train Performance Computer', before the North-Western Measurement and Control Group	20	High-Power Transmitting Valves with Thoriated Filaments for Use in Broadcasting. H. S. Walker, M.B.E., W. H. Aldous, B.Sc., R. G. Roach, B.Sc., J. B. Webb, D.F.H., and F. D. Goodchild, B.Sc.(Eng.)	172
The Performance of a Balanced Aerial when connected directly to a Coaxial Cable. G. D. Monteath, B.Sc., and P. Knight, B.A.	21	An Improvement to the Electron-Trajectory Tracer. J. Vine, M.Sc., and R. T. Taylor	181
Classes of 4-Pole Networks having Non-Linear Transfer Characteristics but Linear Iterative Impedances. Prof. E. Colin Cherry, D.Sc.(Eng.)	26	Improvements in the Precision Measurement of Capacitance. G. H. Rayner, B.A., and L. H. Ford, M.Sc.	185
Phase-Shift Keying in Fading Channels. H. B. Voelcker	31	Ferroresonant Systems of Circuit Logic. Prof. J. G. Santesmases, M. Alique, Dr.Sc., and J. L. Lloret, Bs.Sc.	190
An Analysis of a Type of Comb Filter. A. G. J. MacFarlane, B.Sc.	39	Impedance/Frequency Characteristics of Glow-Discharge Reference Tubes. F. A. Benson, D.Eng., Ph.D., and P. M. Chalmers, B.Eng.	199
The Measurement of Atmospheric Radio Noise by an Aural Comparison Method in the Range 15-500 kc/s. J. Harwood, M.A., Ph.D., and B. N. Harden, M.Sc.	53	The Principle of Reversed Lag applied to On-Off Temperature Control. H. Sutcliffe, M.A.	209
An Experimental Investigation of a Two-Cavity Klystron operating under Large-Signal Conditions. I. M. Stephenson, Ph.D., M.Sc., B.Sc.	60	The A.C. Operation of Ion Chambers at High Fluxes. J. Watson, B.Sc., S.M., Ph.D.	216
The Use of a Wire-Wound Helix to form a Circular H ₀₁ Wave-meter Cavity. Prof. H. E. M. Barlow, B.Sc.(Eng.), Ph.D., H. G. Effemey and P. H. Hargrave, B.Sc.	66	Discussion on 'A Novel High-Accuracy Circuit for the Measurement of Impedance in the A.F., R.F. and V.H.F. Ranges'	225
A Coaxial Film Bolometer for the Measurement of Power in the U.H.F. Band. I. A. Harris	67	Frequency Variations of Quartz Oscillators and the Earth's Rotation in Terms of the N.P.L. Caesium Standard. L. Essen, O.B.E., D.Sc., F.R.S., J. V. L. Parry, M.Sc., and J. McA. Steele, B.Sc.(Eng.)	229
A Transistor Quadrature Suppressor for A.C. Servo Systems. I. C. Hutcheon, M.A., and D. N. Harrison	73	Discussion before a Joint Meeting of the Measurement and Control Section and the Electronics and Communications Section	232
Discussion on 'A Survey of Performance Criteria and Design Considerations for High-Quality Monitoring Loudspeakers', before the North Midland Centre	83	Electrical Units and Standards (Review of Progress). P. Vigoureux, D.Sc.(Eng.)	235
Discussion on 'A New Cathode-Ray Tube for Monochrome and Colour Television', before the Sheffield Sub-Centre	84	Surface Waves: a Proposed Definition. Prof. H. E. M. Barlow, Ph.D., B.Sc.(Eng.)	240
Some Comments on the Classification of Waveguide Modes. A. E. Karbowiak, B.Sc.(Eng.), Ph.D.	85	Frequency Patterns for Multiple-Radio-Channel Routes. B. B. Jacobsen, B.Sc.(Eng.)	241
Some Comments on Quasi-Optical Methods at Millimetre Wavelengths. (Contribution.) L. Lewin	91	Discussion before the Electronics and Communications Section	249
Discussion on the above paper and contribution before the Electronics and Communications Section	91	A Quadrature Network for Generating Vestigial-Sideband Signals. G. G. Gouriet and G. F. Newell	253
An Analogue Electronic Multiplier using Transistors as Square-Wave Modulators. P. Gleghorn, B.Sc.(Eng.)	94	Rectifier Modulators with Frequency-Selective Terminations. D. P. Howson, M.Sc., and Prof. D. G. Tucker, D.Sc.	261
Discussion before the Measurement and Control Section	100	The Input Impedance of Rectifier Modulators. Prof. D. G. Tucker, D.Sc.	273
Theory of the Travelling-Wave Parametric Amplifier. Prof. A. L. Cullen, Ph.D.	101	Discussion on the above three papers before the Electronics and Communications Section	281
Some Properties of Travelling-Wave Resonance. J. R. G. Twisleton, B.Sc.	108		
Saturation Effects in a Travelling-Wave Parametric Amplifier. A. Jurkus, B.Sc.A., and P. N. Robson, B.A.	119		

	PAGE		PAGE
The Corona Discharge and its Application to Voltage Stabilization. E. Cohen and R. O. Jenkins, Ph.D.	285	Discussion before the Measurement and Control Section	461
A Simple Method for Predicting the Characteristics of Tape Structures. J. Allison, Ph.D., B.Sc.(Eng.)	295	An Automatic Continuous Denier Recorder for Synthetic Textile Yarns. C. D. Rutter, B.Sc.(Eng.), R. D. Wright, B.Sc.(Eng.), R. N. Aldrich-Smith, M.Sc., and E. J. R. Hewitt, M.A.	466
Measurement of Transistor Characteristic Frequencies in the 20-1 000 Mc/s Range. J. Bickley, B.Sc.(Eng.)	301	The Design of Controlled Rectifiers using Triode Transistors. E. E. Ward, Ph.D.	473
Comparison of Gain, Bandwidth and Noise Figure of Variable-Reactance Amplifiers and Convertors. J. D. Pearson, M.Sc., and J. E. Hallett	305	Anode Luminescence in Oxide-Cathode Receiving Valves. H. N. Daglish, B.Sc., Ph.D.	481
A Study of Atmospheric Radio Noise received in a Narrow Bandwidth at 11 Mc/s. C. Clarke	311	Planning and Installation of the Sound Broadcasting Headquarters for the B.B.C.'s Overseas and European Services. F. Axon, D.C.M., and O. H. Barron, M.B.E., B.Sc.	485
The Design and Use of Instruments for Counting Local Lightning Flashes. F. Horner, M.Sc.	321	Discussion before the Electronics and Communications Section	496
Development of the Formulae of Electromagnetism in the M.K.S. System. P. Vigoureux, D.Sc.(Eng.)	331	Henri de France Colour Television System. R. Chaste, Ing.É.S.É., L.ès.Sc., and P. Cassagne, Ing.É.N.S.T., L.ès.Sc.	499
Discussion before the Measurement and Control Section and the Southern Centre	337	Discussion before the Electronics and Communications Section	507
An Introduction to the Theory of Solid-State Masers. P. N. Butcher, Ph.D.	341	Discussion on 'The Application of Transistors to Line-Communication Equipment', before the North Staffordshire Sub-Centre	511
Discussion before the Electronics and Communications Section	352	A New H ₁₀ to H ₂₀ Mode Transducer. C. C. Eaglesfield, M.A., Y. Klinger, Ph.D., and L. Solymar	512
Determination of the Dielectric Properties of Low-loss Ceramics at Q-Band Frequencies. J. M. Free, B.Sc., and G. B. Walker, Ph.D., M.A.	354	Non-Reflecting Waveguide Tapers. Prof. H. E. M. Barlow, B.Sc.(Eng.), Ph.D.	515
Some Mechanisms of Failure of Capacitors with Mica Dielectrics. A. A. New, M.Sc.	357	A New Cavity-Resonator Method for Measuring Permittivity. J. K. Sinha, M.Sc., Ph.D., and J. Brown, D.Sc.(Eng.)	522
Analysis of a Frequency-Modulated Continuous-Wave Ranging System. A. J. Hymans, M.Sc., and J. Lait, M.A.	365	Propagation Measurements at 3480 and 9640 Mc/s beyond the Radio Horizon. G. V. Geiger, B.Sc., N. D. La Frenais, B.Sc.(Eng.), and W. J. Lucas, M.Sc.	531
Extra-Terrestrial Radio Noise as a Source of Interference in the Frequency Range 30-1 000 Mc/s. F. Horner, M.Sc.	373	Paraboloidal Reflectors with Axial Excitation. A. R. Donaldson, B.Sc., I. P. French, B.Sc., and D. Midgley, B.Sc., Ph.D.	547
The Long-Term Stability of Fixed Resistors. H. F. Church	377	A Physical Classification of Electromagnetic Waves. Communication by Prof. H. E. M. Barlow, B.Sc.(Eng.), Ph.D.	552
Discussion on 'Design of an Automatic Sensitivity Control for a New Subscriber's Telephone Set', before the North-Eastern Measurement and Electronics Group	386	Telephone Echo Tests. D. L. Richards, B.Sc.(Eng.), and G. A. Buck	553
Discussion on 'The Recognition of Moving Vehicles by Electronic Means', before the Northern Ireland Centre	386	Industrial, Biological and Medical Aspects of Microwave Radiation. A. F. Harvey, D.Phil., B.Sc.(Eng.)	557
Cosmic Radiation (Fifty-First Kelvin Lecture). Prof. C. F. Powell, M.A., Ph.D., Sc.D., F.R.S.	389	A Digital Computer Store with Very Short Read Time. Prof. T. Kilburn, M.A., D.Sc., Ph.D., and R. L. Grimdsdale, M.Sc., Ph.D.	567
Thermistors, their Theory, Manufacture and Application. R. W. A. Scarr, B.Sc.(Eng.), Ph.D., and R. A. Settingington, B.Sc.	395	A Parallel Arithmetic Unit using a Saturated-Transistor Fast-Carry Circuit. Prof. T. Kilburn, M.A., D.Sc., Ph.D., D. B. G. Edwards, Ph.D., M.Sc., and D. Aspinall, M.Sc.	573
Discussion before the Measurement and Control Section and the North-Western Measurement and Control Group	405	Ferrite-Core Memory Systems with Rapid Cycle Times. D. B. G. Edwards, Ph.D., M.Sc., M. J. Lanigan, M.Sc., and Prof. T. Kilburn, M.A., D.Sc., Ph.D.	585
An Analogy between Non-Linear Resistive and Linear A.C. Networks. D. Q. Mayne, M.Sc.(Eng.)	410	High-Speed Light Output Signals from Electroluminescent Storage Systems. G. R. Hoffman, Ph.D., B.Sc., D. H. Smith, M.Sc., Ph.D., and D. C. Jeffreys, M.Sc.	599
V.H.F. Sound Broadcasting. R. V. Harvey, B.Sc.	412	Discussion on the above four papers before the Measurement and Control Section	605
Discussion before the Electronics and Communications Section	421	An Experimental Transistor-Controlled Component Selection and Testing Machine. T. C. Cardwell, B.Sc.(Eng.), J. R. W. Smith, M.Sc., and G. H. King, B.Sc.	608
Sunspot-Cycle Variations in the Discrepancies between Predicted and Observed Frequencies for Use in Radiocommunication. R. J. Hitchcock, M.A., G. O. Evans, B.Sc., and R. Naismith	423	Discussion before the Measurement and Control Section	613
Resistive-Film Milliwattmeters for the Frequency Bands 8.2-12.4 Gc/s, 12.4-18 Gc/s and 26.5-40 Gc/s. I. Lemco, B.Sc., and B. Rogal, B.Sc.(Eng.)	427	The Recording of High-Speed Single-Shot Phenomena. F. E. Whiteway, B.Sc.	615
A Slot-Excited Corner Reflector for Use in Band V (610-960 Mc/s). D. J. Whythe, B.Sc.(Eng.), and K. W. T. Hughes, B.Sc.	431	A High-Resolution Measuring System using Coarse Optical Gratings. B. J. Davies, B.Sc.(Eng.), R. C. Robbins, B.A., C. Wallis, B.Sc., and R. W. Wilde, B.Sc.	624
A Correlator employing Hall Multipliers applied to the Analysis of Vocoder Control Signals. Prof. A. R. Billings, B.Sc., Ph.D., and D. J. Lloyd, B.Sc.(Eng.), Ph.D.	435	Discussion on 'Subscriber Trunk Dialling', before the Western Centre, the Tees-Side Sub-Centre and the Northern Ireland Centre	633
Diffusion of Sound in Small Rooms. K. E. Randall and F. L. Ward, B.Sc.	439	Papers and Monographs published individually	227, 320, 387, 484, 635
A Low-Drift Transistor Chopper-Type D.C. Amplifier with High Gain and Large Dynamic Range. I. C. Hutcheon, M.A., and D. Summers	451	Index	637

PAGES IN PART B, 1960

Pages	No.	Month
1-84	31	January
85-228	32	March
229-320	33	May
321-388	34	July
389-484	35	September
485-636	36	November

ADDITIONAL CORRIGENDA TO VOL. 106, PART B, 1959

Page 50, Fig. 9: The arms of the hybrid ring are incorrectly shown. Starting with POWER INPUT, they should, successively in a clockwise direction, be at 120° , 180° (or 60°) and 300° .

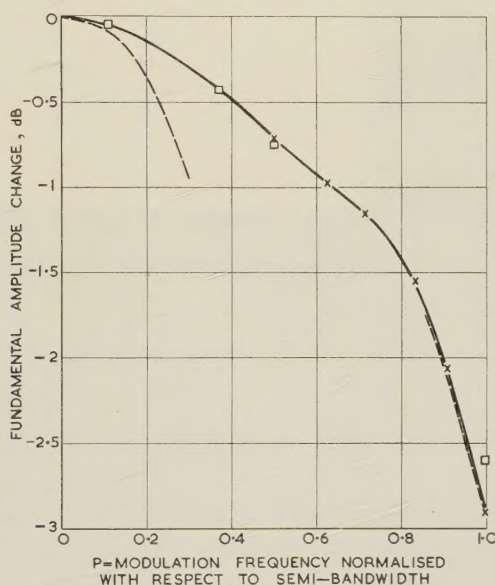
Page 131, Fig. 5: The ordinates should include factors $\times 10^3$ on the left side and $\times 10^{-4}$ on the right.

Page 132, Fig. 7: The curves were taken from Fig. 20 of Reference 26 and represent an approximate solution. The accurate computation of Ref. 10 is for the capacitance per unit length.

Page 139, Ref. 10: p. 85 should read p. 93.

CORRIGENDUM TO VOL. 107, PART B, 1960

Page 158, Fig. 1: The points derived from numerical Fourier analysis and from the extended first-order theory were both misplotted at $p = 0.5$. When correctly plotted there is seen still to be very close agreement between the two methods of analysis. The pronounced kink in the solid curve, as given in the paper, now becomes a point of inflection. This was kindly brought to the author's attention by Mr. J. K. Skwirzynski.



ADDITIONAL CORRIGENDUM TO VOL. 107, PART B, SUPPLS. 15-18

Page 364, col. 1, 4th complete par.: The γ -ray macroscopic cross-sections for silicon and germanium have been recalculated and found to be 0.22 cm^{-1} and 0.43^{-1} respectively, rather than 0.18 cm^{-1} and 0.28 cm^{-1} as given in the paper.

Declaration on Fair Copying.—Within the terms of the Royal Society's Declaration on Fair Copying, to which The Institution subscribes, material may be copied from issues of the *Proceedings* (prior to 1949, the *Journal*) which are out of print and from which reprints are not available. The terms of the Declaration and particulars of a Photoprint Service afforded by the Science Museum Library, London, are published in the *Journal* from time to time.

Bibliographical References.—It is requested that bibliographical reference to an Institution paper should always include the serial number of the paper and the month and year of publication, which will be found at the top right-hand corner of the first page of the paper. This information should precede the reference to the Volume and Part.

Example.—SMITH, J.: 'Reflections from the Ionosphere', *Proceedings I.E.E.*, Paper No. 4001 R, December, 1954 (102 B, p. 1234).

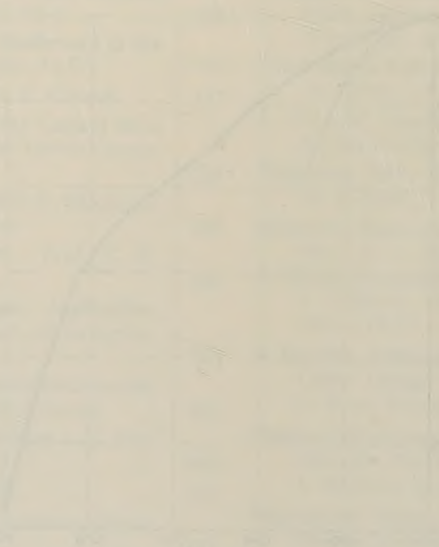
TABLE NO. 1

TABLE NO. 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1



ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1

ADDITIONAL COMMENTS TO THE TABLE NO. 1